

Physics 580
Handout 2
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Quantum Mechanics I
<http://w3.physics.uiuc.edu/~goldbart>
COURSE SYLLABUS

Prof. P. M. Goldbart
2115 & 3135 ESB
University of Illinois

Classical mechanics: principal of least action; lagrangean mechanics, symmetries and conservation laws; hamiltonian mechanics, Poisson brackets and canonical transformations; charged particle mechanics.

Mathematical scaffolding for quantum mechanics: linear vector spaces, Dirac notation, linear operators; hermitean operators; eigenvalue problems and functions of operators; spaces of infinite dimension; self-adjoint operators; the Dirac delta function and Fourier transforms.

Some interesting experiments: the photo-electric effect; Taylor's two-slit experiment; Davisson-Germer experiment; Franck-Hertz experiment; Stern-Gerlach experiment.

Wave mechanics: the time-dependent Schrödinger equation; probability densities and currents.

The postulates of quantum mechanics: the postulates and their meaning; state vectors and operators; the time-evolution of quantum systems and the Schrödinger equation; the Heisenberg picture; complete sets of compatible observables; uncertainty relations; introduction to Feynman path integrals; the classical limit; density matrices.

One-dimensional problems: particles free, in boxes, and near steps; delta function potentials; bound states; periodic potentials, tunnelling.

The simple harmonic oscillator: raising and lowering operators; the eigenvalue spectrum; coordinate space representation; normal modes of oscillation; coherent states.

Orbital angular momentum and rotations: commutation relations for angular momentum; the orbital angular momentum eigenproblem; spherical harmonics; central forces, and the hydrogen atom.

Steady state approximation methods: non-degenerate perturbation theory; degenerate perturbation theory; the Rayleigh-Ritz variational method; Brillouin-Wigner perturbation theory; JWKB semi-classical method; unitary transformations.

Scattering theory: scattering amplitudes and cross-sections; the Born approximation and its validity; partial-wave analysis; bound states and resonances.

Symmetries and conservation laws: discrete and continuous symmetries; parity; translational invariance in space and time; rotational invariance in space; elementary theory of groups and their representations; Lie groups, Lie algebras, and structure constants.

Quantum information: quantum correlations and entanglement; measurements in quantum mechanics; Bell inequalities; processing quantum information.